## WOLFER PROVISIONAL SUN-SPOT RELATIVE NUMBERS.*

The provisional relative sun-spot numbers given in Table 1 herewith are in continuation of the observed relative and the smoothed relative sun-spot numbers published in the REVIEW for July, 1915, **43**: 314.

While these provisional numbers are subject to slight revision, and later will be smoothed by the method described in the REVIEW for April, 1902, **30**: 171, they are sufficiently accurate to show that at the crest of the maximum of 1917 the relative sun-spot number was in excess of 100, which is unusually high.—*H. H. K.*

TABLE 1.—*Wolfer provisional sun-spot relative numbers, January 1915–December, 1918.*

| | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1915 [1] | 25.7 | 35.6 | 34.9 | 42.2 | 35.0 | 69.9 | 71.0 | 68.6 | 44.7 | 53.5 | 38.2 | 32.7 | 46.0 |
| 1916 [2] | 44.3 | 55.4 | 66.5 | 73.3 | 71.4 | 67.7 | 53.0 | 34.1 | 41.4 | 56.0 | 60.7 | 41.0 | 55.4 |
| 1917 [2] | 76.2 | 71.8 | 86.6 | 63.7 | 112.7 | 113.8 | 117.0 | 143.2 | 121.9 | 71.4 | 90.1 | 116.8 | 98.8 |
| 1918 [2] | 96.3 | 63.4 | 72.2 | 76.5 | 76.5 | 62.8 | 104.6 | 94.1 | 73.5 | 86.1 | 68.0 | 54.8 | 77.6 |

[1] Met. Zeit, 1915, **32**: 188, 364, 508, and 1916, **33**: 42.
[2] Terr. Mag. Sept., 1918, **23**: 136, **24**: 43, and others.
* Replacing data in this REVIEW, September and December, 1918, **46**: pp. 403 and 574.

Sun-spot numbers are determined by a somewhat arbitrary rule, but they are approximately proportioned to the spotted area of the sun. One hundred as a sun-spot number corresponds to about one five-hundredth of the sun's visible disk covered by spots.—*Met. Off. Circ., 23, Apr. 25, 1918.*

In reporting on the sun spots observed in the year 1918 Mr. Evershed, director of the Solar Physics Observatory, Kodaikanal, remarks that the maximum spot activity of the present cycle took place during the second half of 1917 for both hemispheres. This judgment may be accepted as correct, for though some hesitation has been felt in accepting this early date lest a secondary maximum should occur after a temporary decline, as has happened in previous cycles, these circumstances do not seem likely to occur. The date of the previous maximum has been placed in the early part of the year 1906, though the sun-spot activity of that year was inferior to that of 1905 and of 1907. Adopting these estimates as correct, the length of the period just ended is slightly above the average.—*Nature (London), June 12, 1919, p. 291.*

## THE WEATHER DATA NEEDED BY ECLIPSE EXPEDITIONS.

In spite of the fact that some of the observing stations for the total eclipse of May 29, 1919, were in the equatorial rain belt, satisfactory results have been obtained.

"In connection with the coming solar eclipse of September 10, 1925, the path of totality of which crosses Mexico, Prof. W. W. Campbell renews a suggestion which has been made by Prof. Todd and other astronomers, viz, that weather observations should be made along the prospective shadow path for a few years before a total eclipse, not only at the season of the year in which the eclipse is to occur, but also at the hour of the eclipse. The observations made at the regular term-hours at meteorological stations often give an entirely erroneous idea of the kind of weather likely to be encountered at the time of an eclipse. Prof. Campbell says that the data supplied to prospective observers of the Russian eclipse of August 21, 1914, were based on observations made in the morning and evening, and gave fair promise of clear skies for the event. After the eclipse parties reached Russia they were surprised to discover that while clear weather was the rule in the evenings and mornings and at night, cloudiness generally prevailed in the middle of the day, reaching its maximum at about the eclipse hour. The Lick Observatory would not have sent an eclipse expedition to Russia if this condition had been known. * * *
—*Sci. Amer., New York, June 21, 1919, vol. cxx*, p. 649.

## LAND AND SEA BREEZES IN THE VICINITY OF CORPUS CHRISTI BAY, TEX.*

By C. E. HECKATHORN, Observer.

[Dated: Weather Bureau, Corpus Christi, Tex., May 17, 1919.]

SYNOPSIS.

Corpus Christi Bay is almost a land-locked body of water, 20 miles wide from east to west and 16 miles from north to south and 14 feet deep. The result of these physical factors is that Corpus Christi Bay is considerably warmer than the Gulf of Mexico, and, at night, very much warmer than the adjacent land areas. It is situated south of the paths of HIGHS and LOWS so that its temperature and winds are little affected thereby. With such striking differences in land, bay, and sea temperatures it follows that the land and sea breezes present an interesting study.—H. L.

Corpus Christi Bay is an almost land-locked body of water about 20 miles in length east and west by about 16 miles in width north and south and is far enough south (north latitude 27° 40′ to 27° 56′) so that the winds and temperatures of the vicinity are not dominated by areas of high and low pressure that cross the United States during the summer season (see fig. 1). It is separated from the Gulf of Mexico by Mustang Island, which is quite narrow and is one of the chain of narrow islands paralleling the Texas Coast. The bay has only two connections with the Gulf of Mexico, Corpus Christi Pass at the south and Aransas Pass at the north end of Mustang Island. Both passes are quite narrow and Corpus Christi Pass is shallow, having a depth of less than 3 feet; allowing only a very limited mixing of the water n the bay with the water in the gulf. Extending southward from the east end of the bay is a long narrow body of water, Laguna Madre, which has no other connection with the Gulf of Mexico except at its southern extremity, over one hundred miles south of Corpus Christi Bay. Laguna Madre is shallow, being less than 1 foot in depth in most places and only a few feet in depth in the deepest places. Extending northeastward from the northeastern extremity of Corpus Christi Bay is Shoal Bay; a body of water similar to Laguna Madre. The Nueces River enters the western extremity of Corpus Christi Bay through Nueces Bay, which is also shallow; permitting the water of the river to be affected by radiation so much before entering Corpus Christi Bay that it is near the temperature of the surrounding land when it enters Corpus Christi Bay. Corpus Christi Bay has an average depth of about 14 feet and is quite uniform in depth except near the shores.

In the summer season, owing to almost uninterrupted insolation, almost complete separation from the Gulf of Mexico, and the relatively high temperature of most of the water entering it, the water of Corpus Christi Bay becomes much warmer than the water in the Gulf of

* For other recent discussions of sea breezes locally on the coast of the United States see "Sea breeze on eastern Long Island," by E. S. Clowes, Monthly Weather Review, 1917, **45**: 345–346; and in "Certain characteristics of the winds at Mount Tamalpais, Calif," by H. H. Wright, ibid., 1916, **44**: 514.—EDITOR.

Mexico. During the daytime in the summer, the water of the bay is much warmer than the water of the Gulf, and at night the water of the bay is considerably warmer than the water of the Gulf and very much warmer than the surrounding land surface.

It is evident that these differences of temperature must have considerable influence on the winds of the vicinity, and it is greatly to be regretted that it has not been possible to take sufficient temperature readings to be able to show the extent of these differences.

The winds of the west Texas coast region, except where influenced by local causes, are from the southeast almost continuously all summer. The land and sea breezes are the principal cause of variations in wind direction and velocity and the winds along the coast are a combination of the prevailing southeast winds and the land and sea breezes, except for the irregular changes caused by the passing of high and low pressure areas and the variation in the intensity of heat over the interior of the continent. As the land and sea breezes never have an opportunity to develop independent of the prevailing southeast winds, their force can be determined only by their modifying influence on the prevailing winds. In clear weather, this modification of the winds is sufficiently great to permit of a fairly accurate estimate of the force and duration of these winds. As the general outline of the coast is nearly due north and south, the land breeze acts from nearly due west and the sea breeze from nearly due east except where influenced by the local heating of the water in Corpus Christi Bay. Since the sea breeze and the prevailing wind blow from so nearly the same direction, it is by means of the differences in the velocities at different hours of the day that the force of the sea breeze can best be judged and by this means of judging, it would appear, that under the best conditions of the atmosphere for insolation in midsummer, the sea breeze on the open coast has nearly as great force as the prevailing wind, which averages about 14 to 16 miles per hour. During the early summer, the prevailing winds are stronger and the sea breezes weaker, and during the late summer both are weaker than in midsummer. The sea breezes diminish very rapidly in force with conditions that are not favorable for strong insolation.

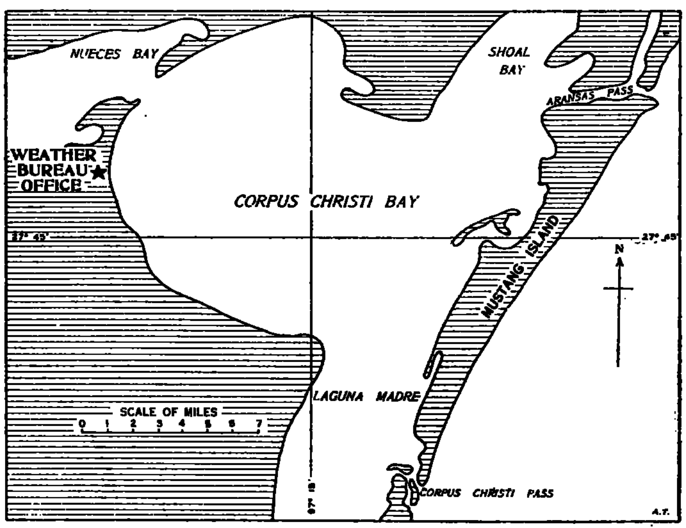


FIG. 1.—Corpus Christi Bay, Tex.

The force of the land breeze can best be judged by the modification of wind direction caused by the land breeze. The land breeze is much weaker than the sea breeze, as is shown by the fact that under the best conditions for radiation the wind in the early morning is a gentle breeze from south-southwest on the immediate coast and nearly due south only a short distance to sea, indicating a force somewhat more than half the force of the prevailing winds.

Corpus Christi, being near the middle of the western end of Corpus Christi Bay, has nearly the same directions for land and sea breezes as have places on the coast north and south of the bay; that is, nearly due east for sea breezes and nearly due west for land breezes, so that whatever influence the bay has on land and sea breezes must be noticeable in changes in velocities rather than in modifications of the directions.

On the coast north and south of Corpus Christi Bay the sea breeze becomes noticeable between 9 and 10 a. m. and is indicated by a rapid rise in velocity and a shifting of the wind toward the east. At Corpus Christi the sea breeze does not become noticeable until between 10 and 11 a. m. and is indicated by a gradual rise in velocity and nearly the same shift in direction as is noticed on other parts of the coast. Along the southern shore of the bay the shift of the wind to the east is somewhat more marked than at Corpus Christi and on the north shore of the bay little if any shift in direction is noticeable, although the gradual rise in velocity is experienced. The later appearance of the sea breeze on the shore of the bay is evidently due to the fact that the bay is so warm that it takes from one to two hours longer in the morning for the land to reach a temperature sufficiently high to develop a sea breeze on the bay shore than on the Gulf shore. It is also noticeable that the wind during the middle of the day is considerably stronger along the Gulf shore than along the shores of the bay. At Corpus Christi on days in which insolation is strong the maximum wind velocity is reached usually about 5 p. m., which is probably somewhat earlier than the time of maximum wind occurrence at points along the Gulf coast.

When the sea breeze becomes well established there is a veering of the wind to nearly the same direction as the prevailing wind, due in part to the greater deflective effect of the earth's rotation on the stronger breeze and in part to the increased speed of the general wind during the hours of considerable convectional activity. Thus, there is no shift of the wind at the time of the dying out of the sea breeze, and the only way of determining the time of the ending of the sea breeze is by noting the time when the velocities decrease. The decrease in velocity begins about 5 p. m. at Corpus Christi, but the decrease, like the morning increase in velocity, is gradual.

The first sign of the appearance of the land breeze at all points along the coast, is a slow shifting of the wind toward the south. The next indication is the forming of small cumulus clouds over the Gulf a few miles outside of the chain of bordering islands. These clouds appear first opposite Corpus Christi Bay and an hour or so later along the rest of the Gulf coast, indicating that the land breeze begins over the bay some time before it begins over the Gulf. These clouds mark the place where the prevailing winds are checked by the land breeze and the surface air of the prevailing wind forced to rise and pass over the land breeze, or, in other words, mark the farthest seaward limit of the land breeze. It is noticeable that these clouds are at about the same distance outside of the bordering islands on the whole coast line and that they are farther out to sea in the morning than they are in the evening. These clouds soon become flattened on their tops, thus showing the well-known shallow depth of the sea breeze and the elevation at which the upper portions of the clouds are carried forward toward the land and dissipated by mixing of the cloudy air with the drier air at that elevation and the drier air rising from the bay. These clouds move slowly toward the north all night. The off-shore clouds are always quite low, although they vary considerably in the elevation of both base and top on different nights. The base of the clouds average in the neighborhood of 800 feet in elevation, which is somewhat higher than the theoretical elevation at which the moisture in the surface air should become sufficiently cooled to condense and form clouds. On clear bright nights, when radiation is most effective, the tops of the offshore clouds are much higher than when radiation is not so effective, which, as would be expected, indicates that the land breezes are much deeper on such nights than on nights when radiation is not so effective. The tops of these clouds are, on an average, about 1,500 feet during July and August and somewhat lower earlier and later in the season. In the morning, soon after the sun begins to warm up the land surface, the offshore clouds begin to move toward the land all along the coast, except opposite Corpus Christi Bay. The offshore clouds opposite the bay move somewhat more rapidly toward the north for more than an hour after the clouds farther north and south have passed inland. When the clouds opposite the bay reach a point nearly opposite the northern extremity of the bay, they turn sharply toward the northwest and move rapidly inland. The wind at Corpus Christi continues to blow from the south-southwest for more than an hour after the clouds north and south of the bay have passed inland.

About an hour and a half after sunrise the wind at Corpus Christi reaches its minimum velocity, which is usually a gentle breeze from the south-southwest, but occasionally from the southwest or west-southwest. After the minimum velocity is reached the wind gradually increases in velocity and shifts toward the southeast. An hour after the minimum velocity has occurred the wind is in the southeast and is increasing rapidly in velocity.

On the whole, it appears that this shallow superheated bay has the effect of delaying the appearance of the sea breeze in the morning and of hastening its end in the evening, as well as of weakening its force while it is blowing, but it would also appear that the course traveled by the sea breeze is somewhat longer than it would be if there were no such body of water to affect it. The land breezes are no doubt lengthened in duration, both in the morning and in the evening, and their force is considerably greater than would be the case if there were no bay.

## LAND AND SEA BREEZES AT BAYONNE, FRANCE.

By M. ROUCH.

[Comptes Rendus, Feb. 10, 1919, vol. 168, pp. 313-315.]

(Translation and abstract.)

From hourly observations of wind velocity and direction made at the aviation center at Bayonne at the southern end of the Bay of Biscay on clear days or days on which the cloudiness did not exceed 4/10, the author brings out the following facts:

1. Table 1, giving hourly components of the wind, was obtained by considering the observed wind at any hour to be made up of two components—i. e., the mean wind for the season and the hourly wind. By taking one side of a parallelogram proportional to the mean wind and the other side proportional to the observed wind, the diagonal gives the hourly wind.

TABLE 1.—*Hourly components of the wind at Bayonne, France.*

| Hours | 1 h. | 2 h. | 3 h. | 4 h. | 5 h. | 6 h. | 7 h. | 8 h. |
|---|---|---|---|---|---|---|---|---|
| Direction | S. 13° E. | S. 22° E. | S. 25° E. | S. 26° E. | S. 27° E. | S. 29° E. | S. 27° E. | S. 24° E. |
| Speed (m. p. s.) | 1.2 | 1.7 | 1.8 | 1.7 | 1.7 | 1.9 | 1.8 | 1.5 |
| **Hours** | **9 h.** | **10 h.** | **11 h.** | **12 h.** | **13 h.** | **14 h.** | **15 h.** | **16 h.** |
| Direction | S. 17° E. | S. 04° E. | N. 66° E. | N. 13° E. | N. 7° W. | N. 12° W | N. 8° W. | N. 11° W |
| Speed (m. p. s.) | 1.2 | 0.7 | 0.2 | 0.5 | 1.4 | 2.3 | 2.9 | 3.0 |
| **Hours** | **17 h.** | **18 h.** | **19 h.** | **20 h.** | **21 h.** | **22 h.** | **23 h.** | **24 h.** |
| Direction | N. 19° W | N. 22° W | N. 36° W | S. 80° W. | S. 78° W. | S. 69° W. | S. 50° W. | S. 44° W. |
| Speed (m. p. s.) | 2.5 | 1.9 | 1.2 | 0.5 | 0.2 | 0.4 | 0.5 | 0.6 |

2. The land breeze is well marked from midnight to 10 a. m., and the sea breeze from 1 p. m. to 7 p. m., with transition periods between. The land and sea breezes do not blow at right angles to the shore line but are inclined to it.

3. The sea breeze is stronger than the land breeze, the speed of the former being 3 m. p. s., while that of the latter is 1.9 m. p. s.

4. No marked influence of high or low tide was noted nor was the velocity of the sea breeze greater on a rising than on a falling tide.

5. Sounding-balloon observations made on 31 clear days give means as follows:

TABLE 2.—*6:30 a. m.*

| Elevation (meters). | 0 | 100 | 200 | 300 | 400 | 500 | 600 | 800 |
|---|---|---|---|---|---|---|---|---|
| Direction | S. 22° E. | S. 7° E. | S. | S. 25° E. | S. 38° E. | S. 51° E. | S. 73° E. | S. 79° E. |
| Speed (m. p. s.) | 0.9 | 1.5 | 1.5 | 1.5 | 2.1 | 2.5 | 3.2 | 3.5 |

| Elevation (meters) | 1,000 | 1,500 | 2,000 | 2,500 | 3,000 | 3,500 | 4,000 |
|---|---|---|---|---|---|---|---|
| Direction | S. 89° E. | N. 84° E. | N. 54° E. | N. 29° E. | N. 25° W. | N. 15° W. | N. 32° W |
| Speed (m. p. s.) | 3.3 | 2.7 | 2.7 | 1.0 | 1.7 | 1.8 | 3.5 |

TABLE 3.—*1 p. m.*

| Elevation (meters). | 0 | 100 | 200 | 300 | 400 | 500 | 600 | 800 |
|---|---|---|---|---|---|---|---|---|
| Direction | N. 31° W. | N. 39° W. | N. 34° W. | N. 25° W. | N. 7° W. | N. 27° E. | N. 70° E. | E. |
| Speed (m. p. s.) | 2.3 | 1.2 | 1.2 | 1.2 | 0.8 | 0.6 | 0.7 | 1.6 |

| Elevation (meters) | 1,000 | 1,500 | 2,000 | 2,500 | 3,000 | 3,500 | 4,000 |
|---|---|---|---|---|---|---|---|
| Direction | S. 87° E. | S. 32° E. | S. 10° E. | S. 25° W. | N. 83° W. | N. 68° W. | N. 53° W. |
| Speed (m. p. s.) | 0.9 | 1.5 | 0.9 | 0.4 | 1.5 | 2.7 | 3.5 |